electric junction exploring the vortex and plat the temperature, or we use some form of hygrometer and determine the dew points. In fact we experimentally determine all the elements that enter into the structure of the waterspout and compare our observations with the theories that have been worked out by Ferrel.

I have said enough for the present. I hope to elaborate this effort to help the mathematician and physicist find a new field full of problems for their students. Thus they will help us to develop the talents of future meteorologists.

These are but special illustrations of the general law that thinking, seeing, and doing must go together. We learn by doing as much as by reasoning—each helps the other. Every theory or hypothesis or suggestion should be reduced to exact formula, exact experiment, exact measurement. Precision is the vital essence of all valuable knowledge.

I hope to live to see special schools of meteorology, special laboratories, and mathematical seminaries devoted to this as to every other profession; but for the present at least I urge that you illustrate the value of and enliven the interest of your mathematical and physical courses by frequently quoting or proposing problems drawn from METEOROLOGY.

ON LIGHTNING AND PROTECTION FROM IT.[1]

By Sir JOSEPH LARMOR, F. R. S.

The rationale of electric discharge in a gas is now understood. When a small region becomes conducting through ionization by collisions in the electric field it should spread in the direction in which the field is most intense, which is along the lines of force. Thus the electric rupture is not a tear along a surface but a perforation along a line. This is roughly the line of force of the field; the electrokinetic force induced by the discharge, being parallel to the current, does not modify this conclusion. A zigzag discharge would thus consist of independent flashes, the first one upsetting adjacent equilibria by transference of charge. Successive discharges between the same masses would tend to follow the same ionized path, which may meantime be displaced by air currents.

If the line of discharge is thus determined by the previous electric field, the influence of a lightning conductor in drawing the discharge must be determined by the modification of this electric field which its presence produces. For a field of vertical force, such as an overhead cloud would produce, it may be shown that the disturbance caused by a thin vertical rod is confined to its own immediate neighborhood. Thus while it provides a strong silent discharge from earth into the air, it does not assist in drawing a disruptive discharge from above—except in so far as the stream of electrified air rising from it may provide a path. It is the broader building, to which the rod is attached, that draws the lightning: the rod affords the means of safely carrying it away, and thus should be well connected with all metallic channels on the building as well as with earth. It is the branching top of an isolated tree that attracts the discharge; a wire pole could not do so to a sensible degree. Separate rods projecting upward from the corner of a building do not much affect the field above it, but if they are connected at their summits by horizontal wires, the latter, being thus earthed, lift up the electric field from the top of the building itself to the region above them, and thus take the discharge which they help in attracting, instead of the building below them. Similarly, when the lines of force are oblique to a vertical rod, its presence does somewhat modify the field and protect the lee side; but generally the presence of a rod should not ever be a source of danger, unless the ionized air rising from it provides an actual path for discharge.

[1] *Reprinted from* Report British Association for the Advancement of Science, 83d meeting, Birmingham, September 10-17, 1913. London, 1914. Section of Mathematical and Physical Science, p. 387.

LIGHTNING INJURY TO COTTON AND POTATO PLANTS.*

By L. R. JONES and W. W. GILBERT.

[*Abstract* of a paper presented to the Sixth Annual Meeting of the American Phytopathological Society, Philadelphia, Dec. 29, 1914-Jan. 1, 1915.]

Literature contains meager data concerning lightning injury to herbaceous plants. The authors have evidence that such injury is not uncommon in certain crops, notably cotton and potatoes, and may occur in beets, tobacco, and ginseng. Grass, small grains, and corn seem less liable. Cotton and potatoes when so struck may be killed in roundish spots, 1 to 3 rods in diameter or sometimes several associated smaller spots. There may be no disturbance of soil or physical rupture of plant tissues. The plants near the center wilt, blacken, and die promptly; about the margins some may live days or weeks. Such weakened cotton plants yellow or redden. The injury appears first and worst from the soil line or a little above downward, but may not kill all the underground parts. Partially injured cotton plants may form callus ridges above point of injury and new potato shoots may sprout from base of injured stems. These various facts suggest the theory that when a sudden electric storm follows upon a period of dry weather, lightning discharge spreads horizontally over the moist surface layer of soil and that certain crops are more liable than others, either because of relative tissue resistance or because of character or distribution of aerial parts or root systems.

WEATHER AND HEALTH.

The Notices of the Imperial Academy of Sciences of Vienna for June 25, 1914, contain a brief statement of the results of a recent investigation of the important question as to the connection between weather and human health, undertaken by Dr. Ernst Brezina and Wilhelm Schmidt at the Austrian Central Meteorological Institute in Vienna and presented to the Academy on June 14, 1914.[1]

Heretofore, as the authors showed, this question has been treated largely if not entirely from the standpoint of the physiologist; therefore it seemed all the more promising to follow more the methods of meteorology and to subdivide the weather more minutely into its elements, thus of course adopting a purely statistical method of treatment.

An unprecedently large and explicit series of meteorological elements, from the records of the Central Meteorological Institute, were compared by a specially appropriate method, day for day, with a series of daily values which presented in a somewhat quantitative manner the condition and behavior of extensive groups of healthy and ill persons. For the present investigation Brezina and Schmidt employed: (1) Records of the average hourly work accomplished by a large number of female employees of the Imperial Census Commission, in punching the counting cards (Zählkarten) (*light mental office work*); (2) the recorded daily number of epileptic attacks (i. e., number of patients affected) among the inmates of the hospital for mental and nervous diseases "Am Steinhof" (*condition of the sick*); (3) daily general estimates of the per-

* *Reprinted by permission* from Phytopathology, No. 6, December, 1914, 4: 406.
[1] *Summarized in* Meteorologische Zeitschrift, Braunschweig, Jan. 1915, 32: 43-44.

formances of the scholars in 60 classes of the Vienna public schools (*mental work of children*).

The carefully worked out results of this extensive investigation were presented in over 100 tables. The most important conclusions may be stated as follows:

1. If the weather exerts any influence at all its effects are restricted to relatively narrow limits.
2. Easy mental work is best carried on under only slight daily pressure changes.
3. Under rapid pressure changes (having periods of 4 to 20 minutes) there was a pronounced falling off in work accomplished, and a poorer condition in patients.
4. Higher temperatures and temperature variations, particularly those of a two-day duration, caused a falling off in mental work; while epilectics seemed to be sensitive to cold.
5. Correlation with other meteorological elements was generally less definite or quite impossible; the latter was particularly true for the quantity of ozone present.
6. If one desires to make use of the usual weather-descriptive methods it appears more desirable to select the isallobaric regions (those of rising and falling pressures) rather than the favorite isobaric regions of highs and lows. The isallobaric regions showed pronounced synchronal relations in all cases, even in the studies of the school children where the other relationships were rather indistinct.

The material collected has been but partially studied so far, and the results here summarized apply only to Vienna in 1912.

The methods employed revealed, of course, only a chronological relationship; direct effects could not be traced here even as well as they might through physiological experiments. However, although these methods do not by any means permit one to unravel the true causes of the phenomena by means of the merely accidental or essential concurrent circumstances, nevertheless these methods have the advantage, among other things, of broad foundations in every direction, of working under natural surroundings and the possibility of summarizing conditions that can not be directly realized in an artificial experiment. Disregarding even these advantages, these studies offer a guide to the direction in which results may be properly sought for in the future.

HUNTINGTON ON THE CLIMATIC FACTOR.[1]

By W. J. HUMPHREYS, Professor of Meteorological Physics.

This latest book by Prof. Huntington, of Yale, fully supports his reputation as a persistent worker, resourceful advocate, and delightful writer. As the title of the book indicates, climatology is the main topic, not climatology as a disconnected and isolated science, but climatology in its relation to and as interpreted by geology, botany, archeology, and ethnology.

Everyone must admit that climate is an important factor in a thousand things, some of which, like the age and growth of trees, the size and course of rivers, the area and depth of lakes, and even the development of nations and the evolution of the human race have accumulated innumerable and invaluable records; fragmentary to be sure, and hard to interpret, but never biased and, taken together, covering every age from the very present to the earliest geologic aeon. It is some of the more conspicuous of these records that Prof. Huntington and others, at the expense of a great deal of labor, have brought together and discussed in the book under review. For the data themselves we must be thankful. No climatologist whose vision extends beyond yesterday's meteorological records can afford to ignore them. In regard, however, to any climatic hypothesis one may fashion to fit the observed facts it is necessary to be conservative and cautious. Of course, a working hypothesis is often a great help to progress, and Prof. Huntington has wisely been bold enough to further his own work in this way. He assumes that during historic times there have been a number of extensive, probably world-wide, climatic changes, especially changes in the amount of precipitation; that they were irregular in occurrence, intensity, and duration; and that some of them lasted several centuries. This is certainly a good working hypothesis and the author legitimately and cleverly endeavors to support it with data from a number of independent sources. The big trees of California, for instance, are as independent of the Maya ruins of Yucatan as of the rings of Saturn, and yet in the hands of Prof. Huntington the Maya ruins and the big trees tell the same tale of centuries-long climatic changes. But in spite of all this cumulative evidence the author is frank enough to say of his hypothesis (p. 224), in the open-minded spirit of the true investigator:

> Doubtless it will be further modified; doubtless I have ascribed to it some results really due to other causes; but that is an inevitable stage of a new subject. The only question is: How far does the present theory harmonize with the great body of facts by which it has been or may in future be tested? So far as it does so, we may tentatively accept it. So far as it does not, it must be rejected.

Surely this statement is fair enough to disarm any combative opponent.

But to be more specific and more critical:

The interesting fact, discussed on pages 12 and 13, that in southern Arizona at high altitudes winter precipitation is greater than that of summer while at low altitudes it is less than that of summer does not seem to the reviewer to indicate, as suggested, any climatic peculiarity or to be at all mysterious. The winter precipitation in Arizona, as elsewhere, is largely the result of topographic deflections of otherwise horizontally moving winds, and hence is greatest at considerable altitudes. On the other hand, the summer precipitation is due almost wholly to the strong vertical convection of thunderstorms whose formation is especially favored by the high temperatures of the valleys and plains. In short, the phenomenon in question appears to be fully accounted for by the difference in the summer and winter processes of inducing precipitation; that is, topographic deflection and heat convection.

On page 90 it is stated that "the more severe climatic changes of the present time appear to be, in general, synchronous in the United States and Europe. This was evident in the summer of 1911, when England was so dry as to be changed from a green land to a brown, and the eastern United States had the hottest, driest season for a century." The first statement, that in general the climates of Europe and the United States vary together, is true, but the data for the single year 1911, or any other, is no proof of it. Besides, the statement that during the summer of 1911 "the eastern United States had the hottest, driest season for a century" may need some modification, in the light of the accompanying table made up from Weather Bureau records. Instead of that season being the "driest for a century," it appears actually to have been wetter than usual.

[1] The Climatic Factor as illustrated in arid America. By Ellsworth Huntington, with contributions by Charles Schuchert, Andrew E. Douglass, and Charles J. Kullmer. Washington, 1914. vi, 341 p. 12 plates, 2 maps, 90 text cuts. 4°. (Carnegie Institution of Washington, Publ. No. 192.) $5.50.